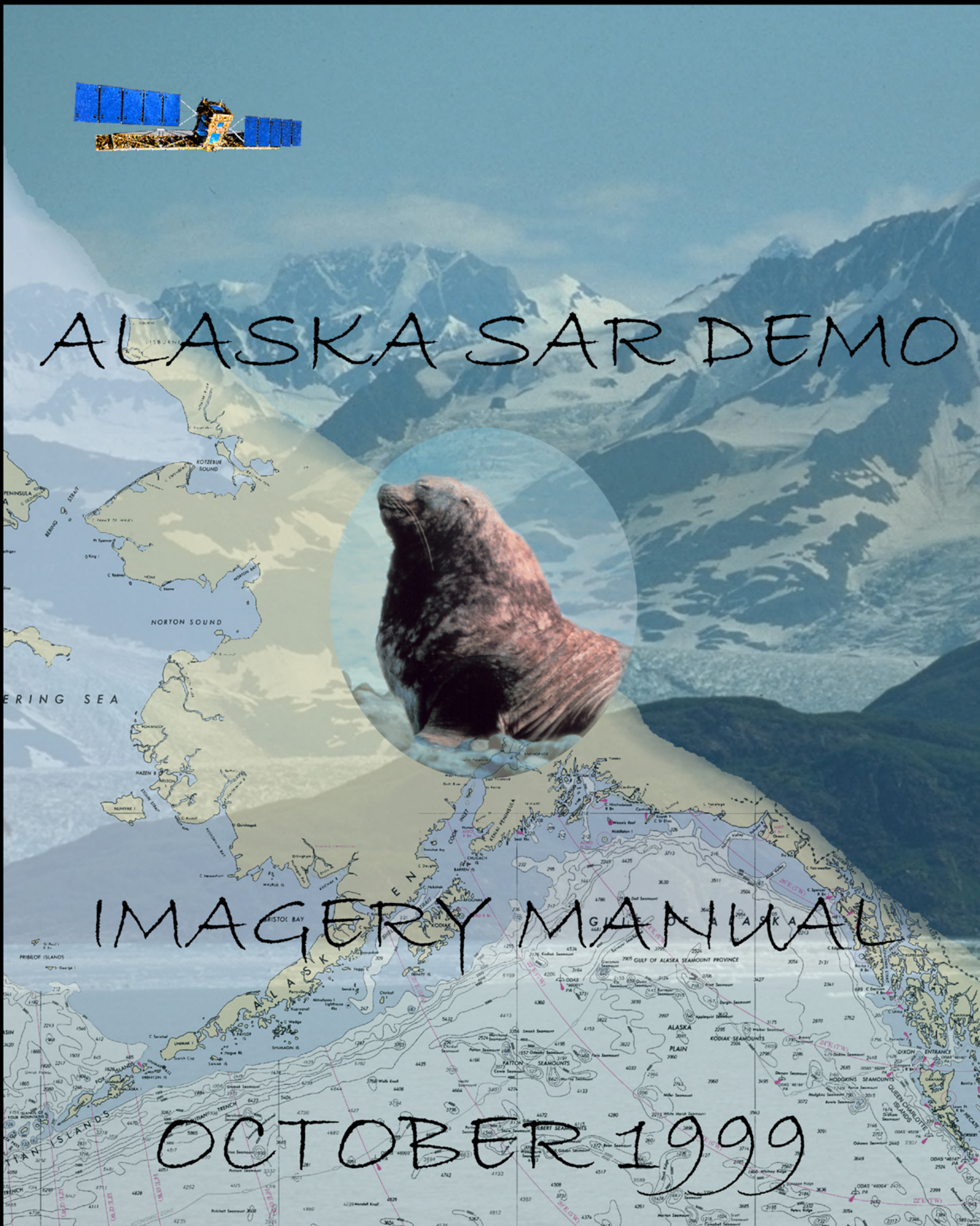
ALASKA SAR DEMO

IMAGERY MANUAL

OCTOBER 1999



Alaska SAR Facility ~ NOAA NESDIS ~ ERIM International Inc. ~ JHU Applied Physics Lab ~ Applied Coherent Technologies ~ NWS ~ U.S. Coast Guard ~ Alaska Department of Fish and Game ~ National Marine Fisheries Service ~ JPL ~

SAR IMAGERY INTERPRETATION MANUAL

NESDIS Monitoring and Demonstration Project

(NEMoDe) NOAA/NESDIS/ORA

Washington, D.C.

NEMoDe and the Alaska SAR Demonstration are supported by the NESDIS Ocean Remote Sensing Program (NORS)

September, 1999

SAR IMAGERY INTERPRETATION MANUAL

TABLE OF CONTENTS

ATMOSPHERIC FRONT

Date: 5/10/98
Time: 15:43:11 GMT
Location:
Gulf of Alaska
64N, 161.5W
Mode:
ScanSAR Wide B

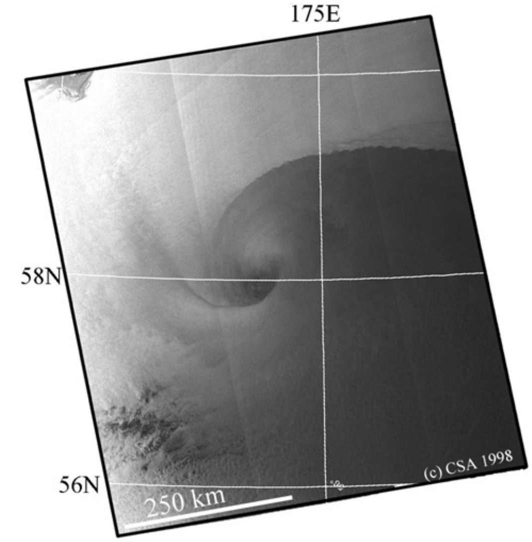
Date: 12/2/98
Time: 18:55:41 GMT
Location:
Bering Sea
60N, 170E
Mode:
ScanSAR Wide B

Top:
The linear features on the right half of the image are caused by wind associated with an atmospheric front. Often there is a band of clouds directly above these SAR features. The left half of the image contains convection cells (see convection cells).

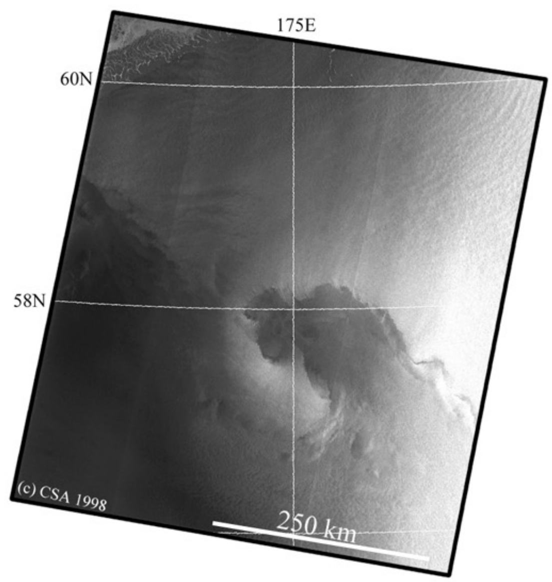
Bottom:
This front is possibly part of a polar mesoscale cyclone (see polar low). The wind is blowing diagonally from right to left as can be seen by the wind shadowing near land (see wind shadowing). The shear force between two regions of different wind speeds causes the wave-like shape of the frontal boundary. Also, smaller gravity waves are seen perpendicular along the front.

POLAR LOWS-COMMA TYPE

Date: 2/5/98
Time: 6:02:27 GMT
Location:
Bering Sea
58N, 175E
Mode:
ScanSAR Wide B

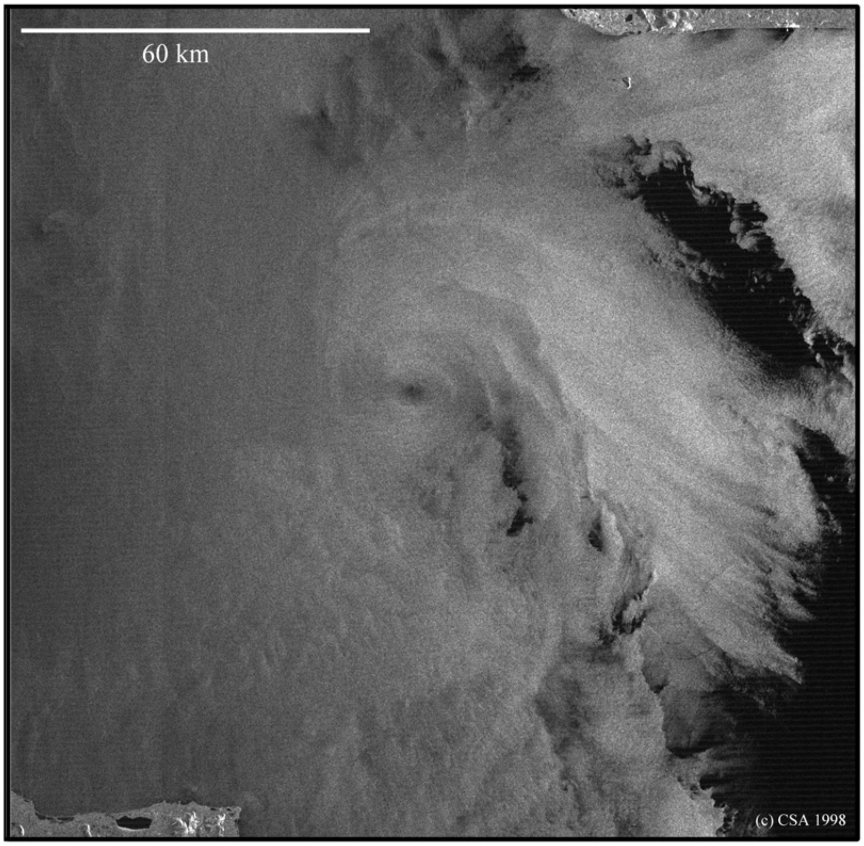


Date: 2/14/98
Time: 18:43:00 GMT
Location:
Bering Sea
58N, 175E
Mode:
ScanSAR Wide B



The two polar lows (or polar mesoscale cyclones) on this page are both of the comma type, but vary in their appearance. Both are associated with hook-like cloud formations in the atmosphere. They have northerly wind boundaries spiraling to the center, which are visible as the boundary between higher wind (lighter) and lower wind (darker). This boundary is distorted by shear waves caused by the difference in wind speeds, though the top image has waves of much smaller scale. Polar lows can be 100 to 1000 km and form most often from fall to spring as a result of air flow over cold land or ice regions.

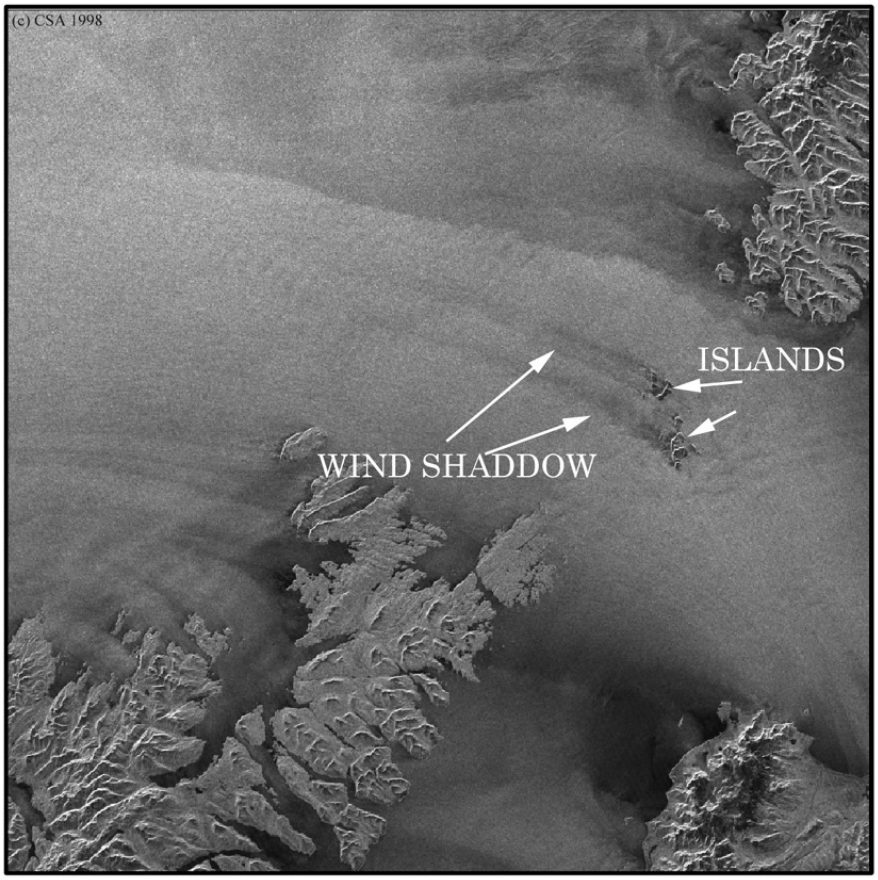
POLAR LOW-SPIRAL TYPE



Date:10/24/98
Time: 17:51:00 GMT
Location:
Bering Sea
648N, 167W
Mode:
ScanSAR Wide B

The spiral-type polar low is more like a hurricane, with a distinct eye. It is otherwise similar in characteristics to a comma-type polar low.

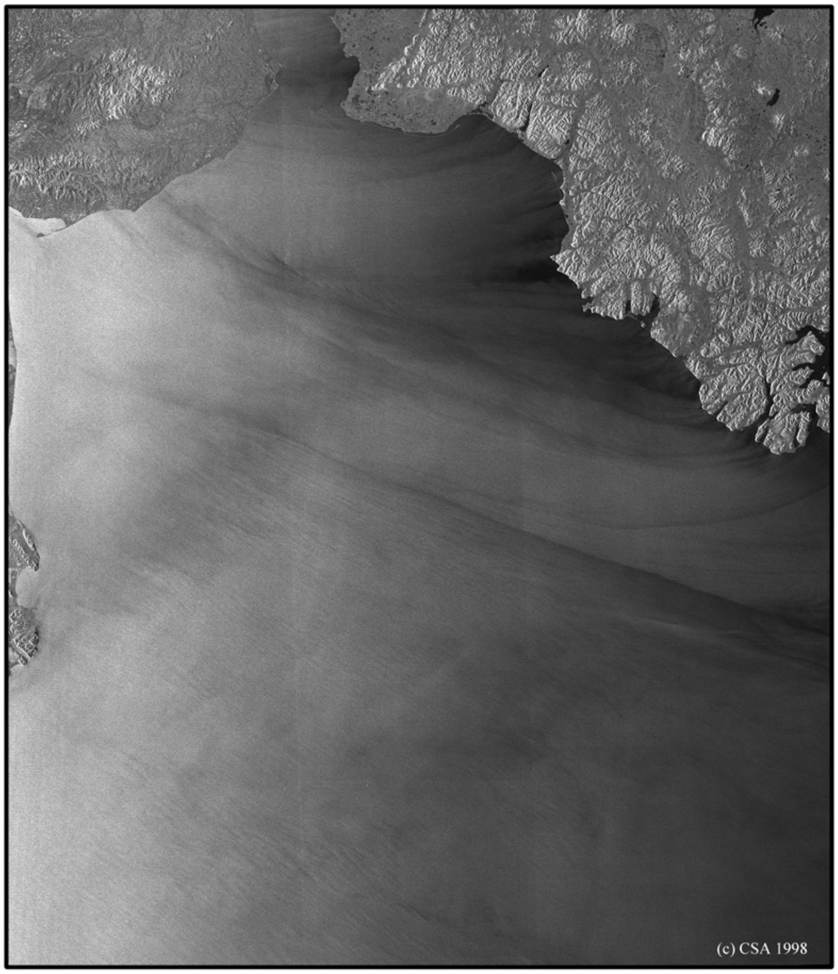
WIND SHADOW



Date: 10/6/98
Time: 16:37:10 GMT
Location:
Cook inlet
59N, 152W
Mode:
ScanSAR Wide B

High terrain can shield the coastal ocean from winds. These low-wind ocean regions appear as darker features or wind shadows on SAR imagery.

WIND ROWS

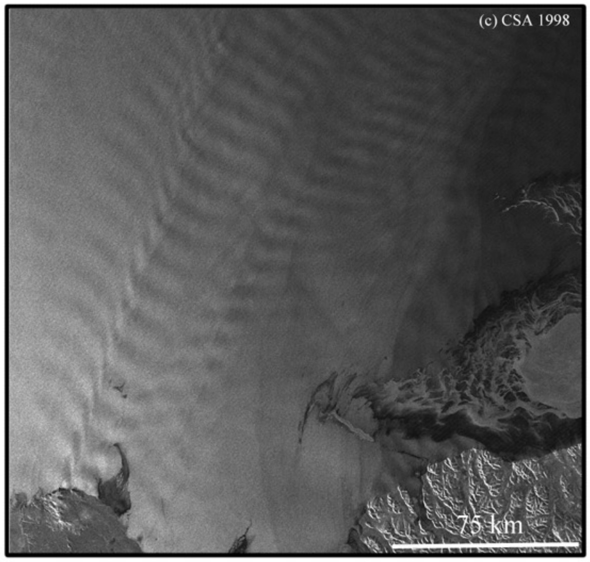


Date: 7/23/99
Time: 5:17:54 GMT
Location:
Bering Sea
64N, 177W
Mode:
ScanSAR Wide B

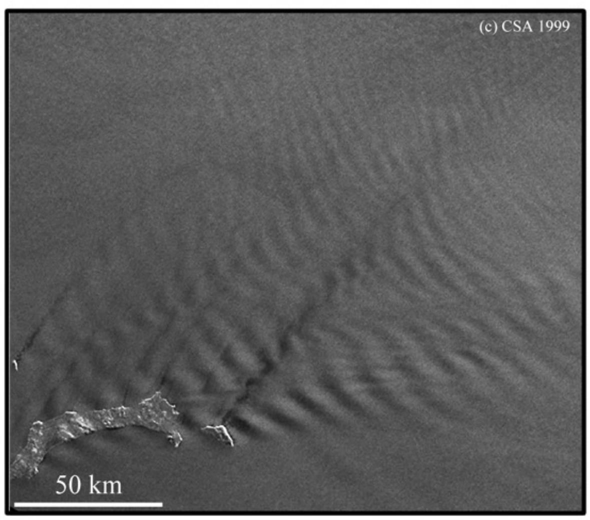
Wind rows or wind rolls are linear features associated with horizontal roll vortices in the atmospheric planetary boundary layer. Variations in the surface wind caused by the roll vortices produce these features which appear in SAR imagery as a streak-like patterns extending in the direction of the roll vortices. The spacing between wind rows, usually several kilometers, can range from two to four times the depth of the planetary boundary layer.

ATMOSPHERIC LEE WAVES

Date: 12/24/98
Time: 18:12:47 GMT
Location:
St. Lawrence Is.
63.5, 171W
Mode:
ScanSAR Wide B



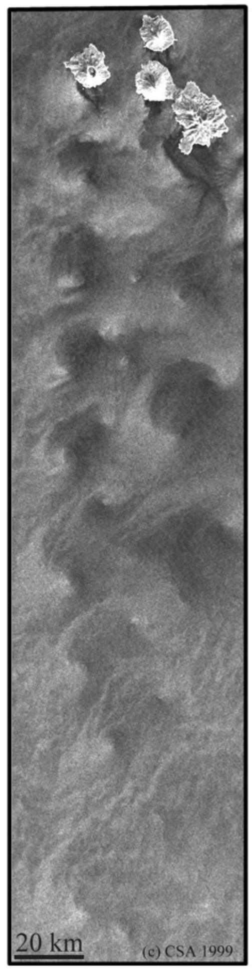
Date: 1/5/99
Time: 5:21:14 GMT
Location:
St. Matthew Is.
60.5, 131W
Mode:
ScanSAR Wide B



As stratified air flows over a mountain or an island, it often sets up large standing atmospheric gravity waves called atmospheric lee waves. The wind velocity fluctuation at the sea surface associated with the lee waves modulates the sea surface roughness, and thus can be imaged by SAR as bright and dark features on the lee side of the obstacle.

ATMOSPHERIC VORTEX STREETS

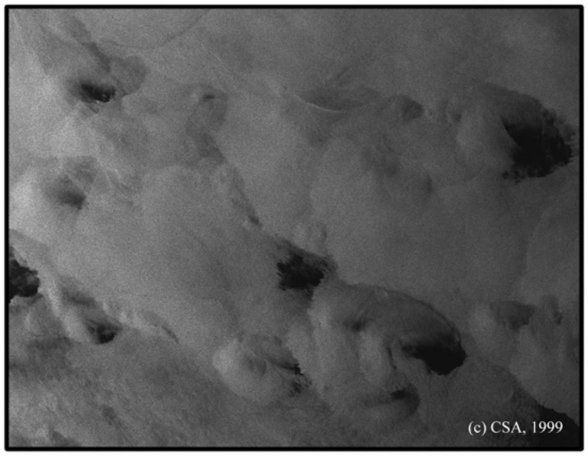
Date:5/5/99
Time: 17:25:41GMT
Location:
Aleutian Islands
53N, 170W
Mode:
ScanSAR Wide B



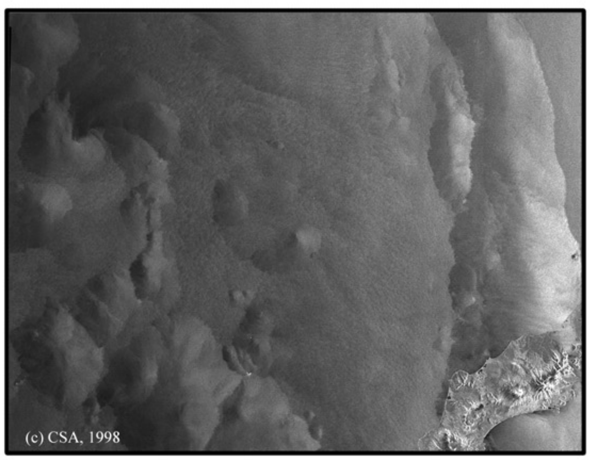
When air flows around an obstacle, such as a mountain or island, atmospheric vortex streets can develop on the lee side of the obstacle under favorable conditions. The atmospheric vortex streets pattern consists of a double row of counter rotating vortex-pairs shedding alternately near each edge of the obstacle and resembles the classic Von Karman vortex-street patterns. The bright spots on either side of the low wind speed pattern are the atmospheric vortices. The atmospheric vortex streets length is about 190 km in this case.

CONVECTION CELLS

Date: 3/22/99
Time: 3:23:03 GMT
Location:
Gulf Of Alaska
58N, 150W
Mode: Standard

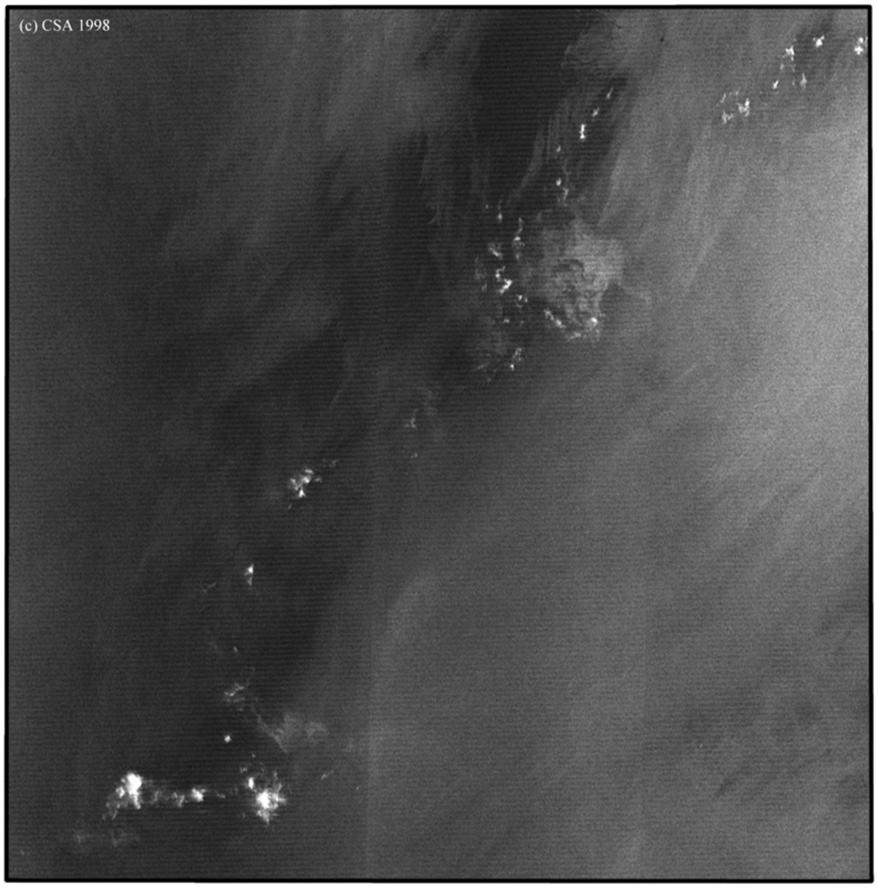


Date: 11/1/98
Time: 17:20:06 GMT
Location:
Aleutian Islands
55N, 165W
Mode:
ScanSAR Wide B



Convection cells are observed by SAR due to the Bragg wave modulation caused by the downdraft wind pattern. Rain and viewing geometry are also important in producing convection cell signatures in SAR. Convection cells usually exhibit a brighter side, which in most cases faces the direction of the radar. Attenuation effects from the rain due to either column content or Bragg wave damping can produce areas of reduce backscatter within the cell

ATMOSPHERIC BRIGHT SPOTS

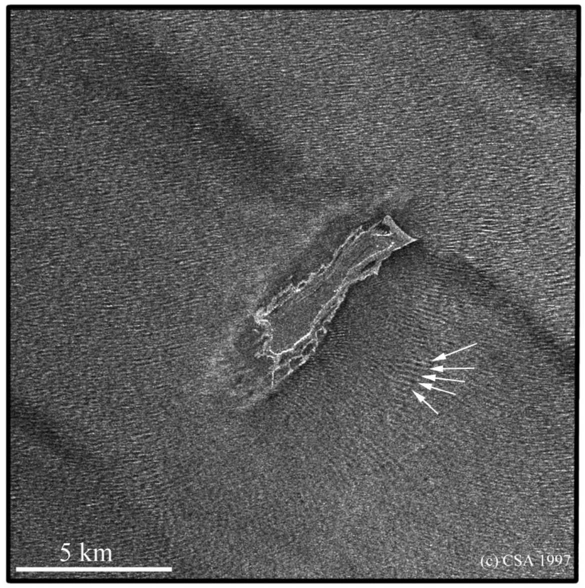


Date: 7/23/98
Time: 18:04:54 GMT
Location:
Bering Sea
62N, 175W
Mode:
ScanSAR Wide B

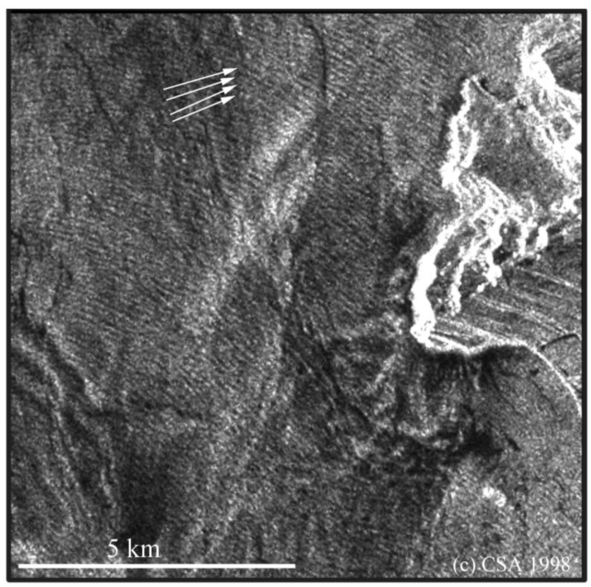
Bright spots are commonly seen in SAR imagery of storm systems. These features are possibly caused by the high radar reflectivity of cloud ice produced by strong convective cells.

OCEANIC LONG SURFACE WAVES

Date: 11/10/97
Time: 3:19:08 GMT
Location:
Middleton Island
59.4N, 146.3 W
Mode: standard



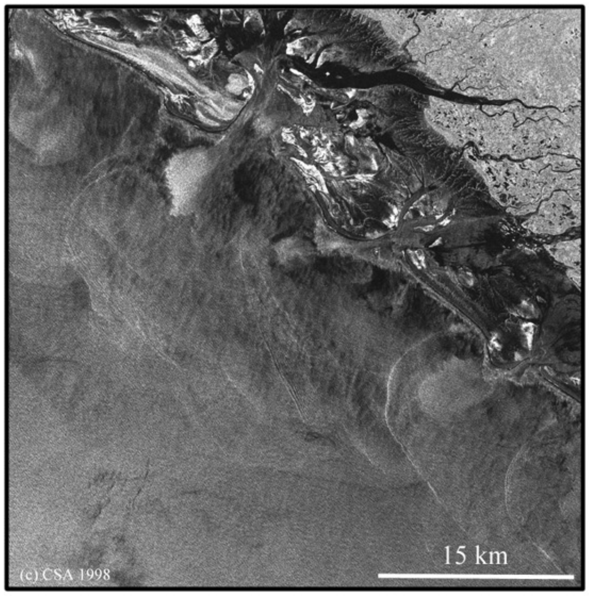
Date: 6/11/98
Time: 3:07:02 GMT
Location:
Prince William Sound
60.3N, 146.8 W
Mode: standard



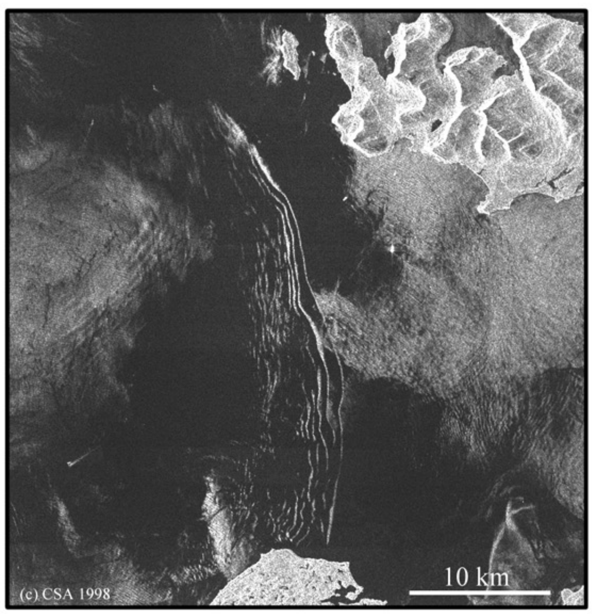
Oceanic long surface waves can be generated by the forcing on the ocean surface from sustained local winds or remote large scale events, such as a hurricane. Their wavelengths vary with their origin and are typically 40 to 60 m for locally produced waves and over 200 m for waves produced from a large storm event. SAR images of the ocean surface can show the diffraction and refraction of oceanic long surface waves around islands and bottom topography features. These two SAR images show that the wave ray changes when the incoming wave approaches the shallow area around the island.

OCEANIC INTERNAL WAVES

Date: 6/11/98
Time: 3:06:49 GMT
Location:
Prince William Sound
60N, 146W
Mode: standard



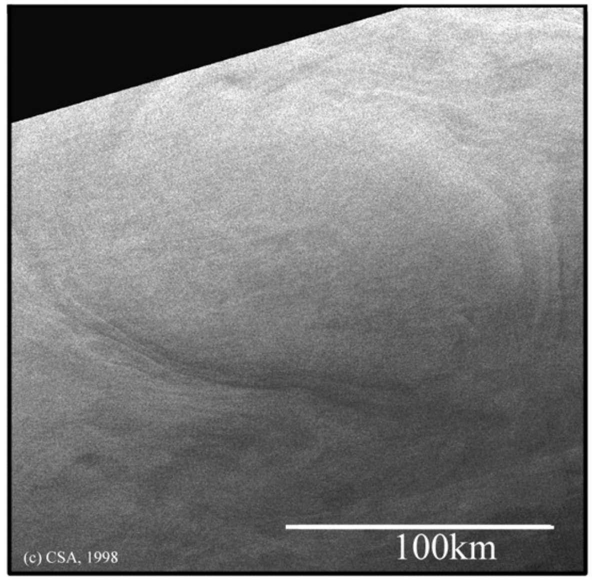
Date: 6/11/98
Time: 3:07:02 GMT
Location:
Prince William Sound
60.5N, 146.6W
Mode: standard



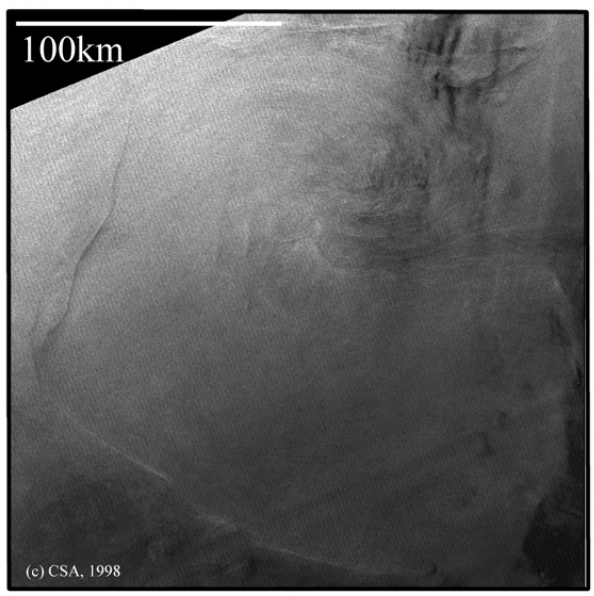
Oceanic internal waves are frequently observed on the continental shelf during the summer season, when the ocean is stratified. These waves, usually produced by tidal forcing, propagate along the density interface as highly coherent packets with several wave crests in each packet. The internal waves affect the surface current field, which modulates the Bragg waves, allowing them to be imaged by SAR.

OCEANIC EDDIES

Date: 4/16/98
Time: 15:43:02 GMT
Location:
Gulf of Alaska
56N, 138W
Mode:
ScanSAR Wide B

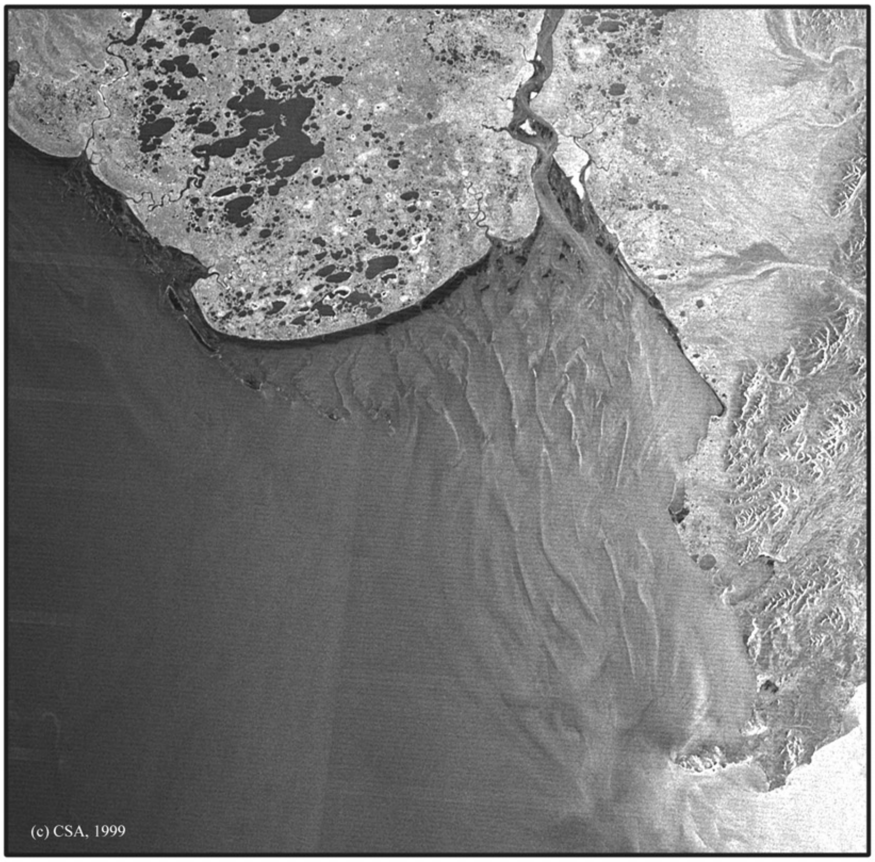


Date: 4/22/98
Time: 16:07:56 GMT
Location:
Gulf of Alaska
58N, 144W
Mode:
ScanSAR Wide B



These two SAR images were acquired in the Gulf of Alaska. The circular patterns observed in these images are produced by current fronts associated with oceanic eddies. Both, backscatter changes due to velocity changes across the current fronts as well as convergence and advection of natural film contribute to the imaging of these features.

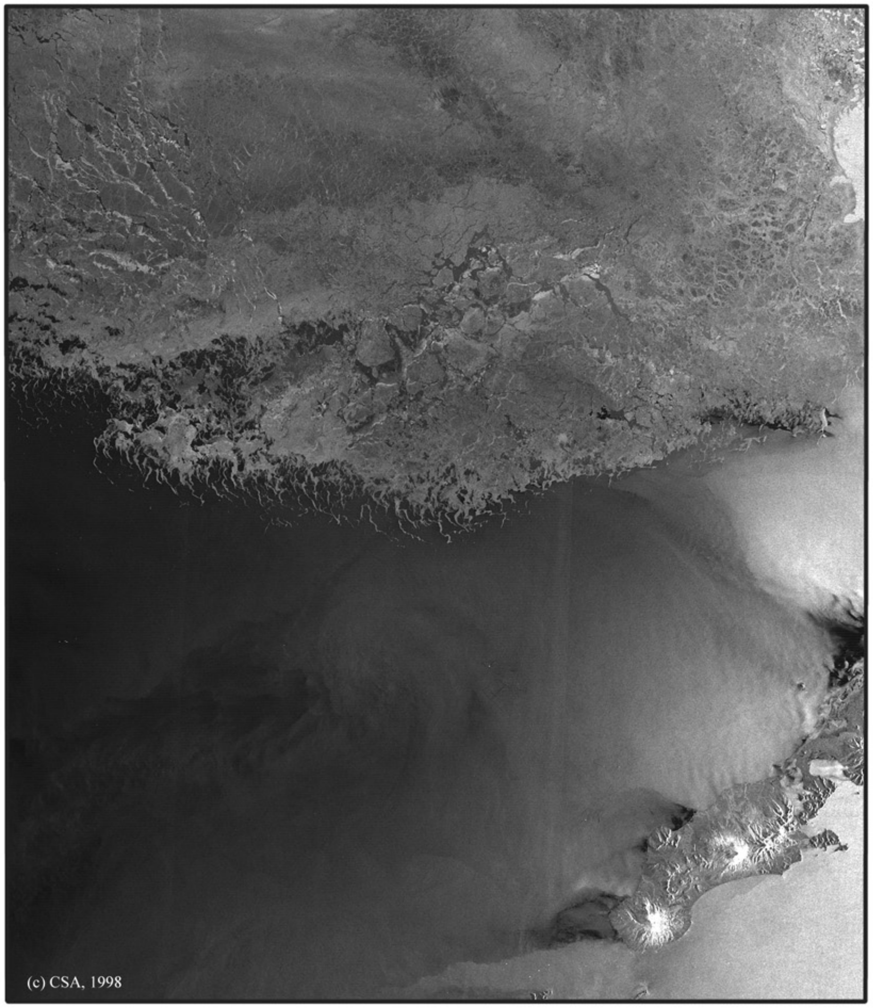
BATHYMETRY



Date: 7/16/99
Time: 17:23:18 GMT
Location:
Kuskokwim Bay
60N, 163W
Mode:
ScanSAR Wide B

Bathymetric signatures are imaged in SAR when the interaction of the ocean current with bottom topography produces variations in the surface current velocity therefore modulating the Bragg waves. They usually exhibit a decrease in the backscatter intensity on one side of the bathymetric feature and an increase on the other. This can be explained by a change in Bragg wave amplitude due to a change in the current induced by the bathymetric features. Bathymetric SAR signatures such as the sand bars shown in the image have generally been observed under relatively strong currents (over 40 cm/s) and in shallow water depths (less than 50 m). Extremely shallow areas such as exposed or nearly exposed mud flats and marshes may appear as dark regions as shown in the image.

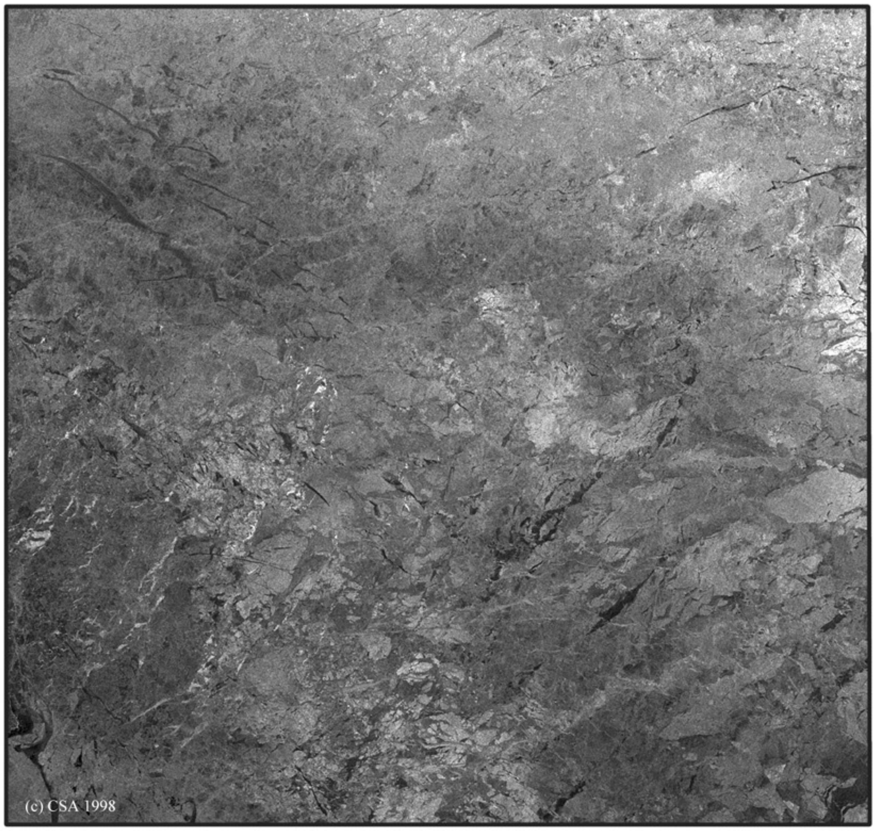
ICE EDGE



Date: 2/3/98
Time 17:24:04 GMT
Location:
Aleutian Islands
56N, 165W
Mode:
ScanSAR Wide B

This is an image the southern edge of the winter pack ice just north of the Aleutian Islands in the Bering Sea. Approaching the ice edge from the north, there are melt ponds (dark areas) on the ice. Ridges and rougher ice regions are bright. At the very edge, streamers of loosely consolidated wet ice are separated by open water.

PACK ICE

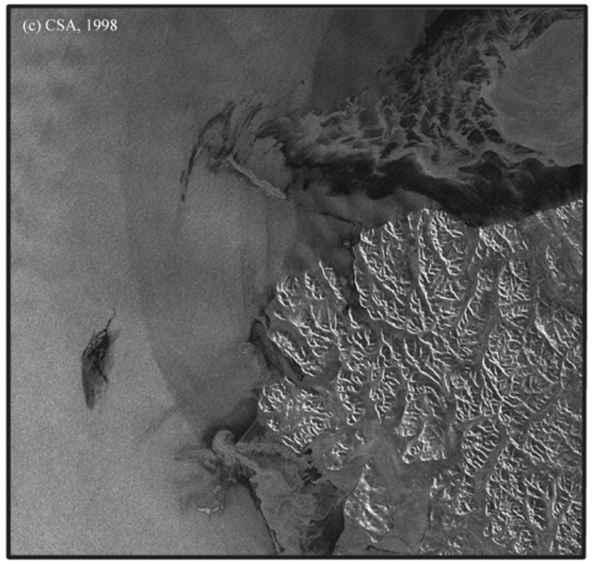


Date: 12/17/98
Time: 4:37:42 GMT
Location:
Chukchi Sea
70N, 170W
Mode:
ScanSAR Wide B

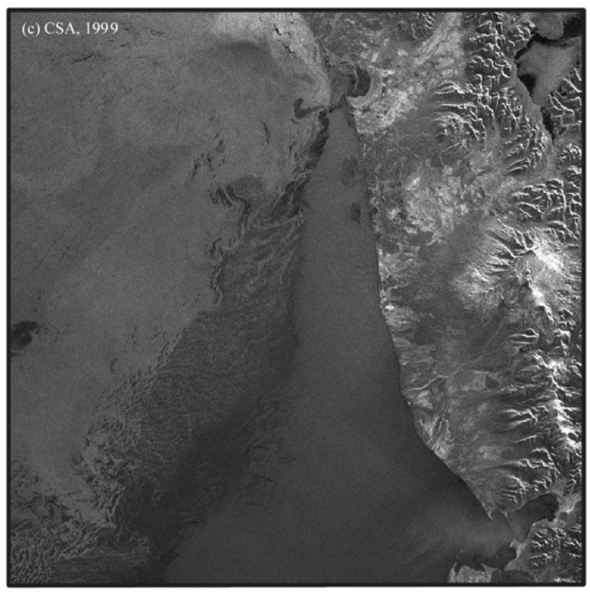
This is an image of the sea ice pack during the winter in the Chukchi Sea. It shows mostly first year ice (darker gray shades), with some rounded multi-year floes (lighter gray). Bright regions are rougher ice. The darkest regions are open, calm water or smooth new ice (perhaps grease ice). The long linear dark features are leads, which may contain open water, grease ice, or other types of very thin ice.

GREASE ICE

Date: 12/24/98
Time: 18:12:47 GMT
Location:
Bering Sea
64.5N, 173W
Mode:
ScanSAR Wide B

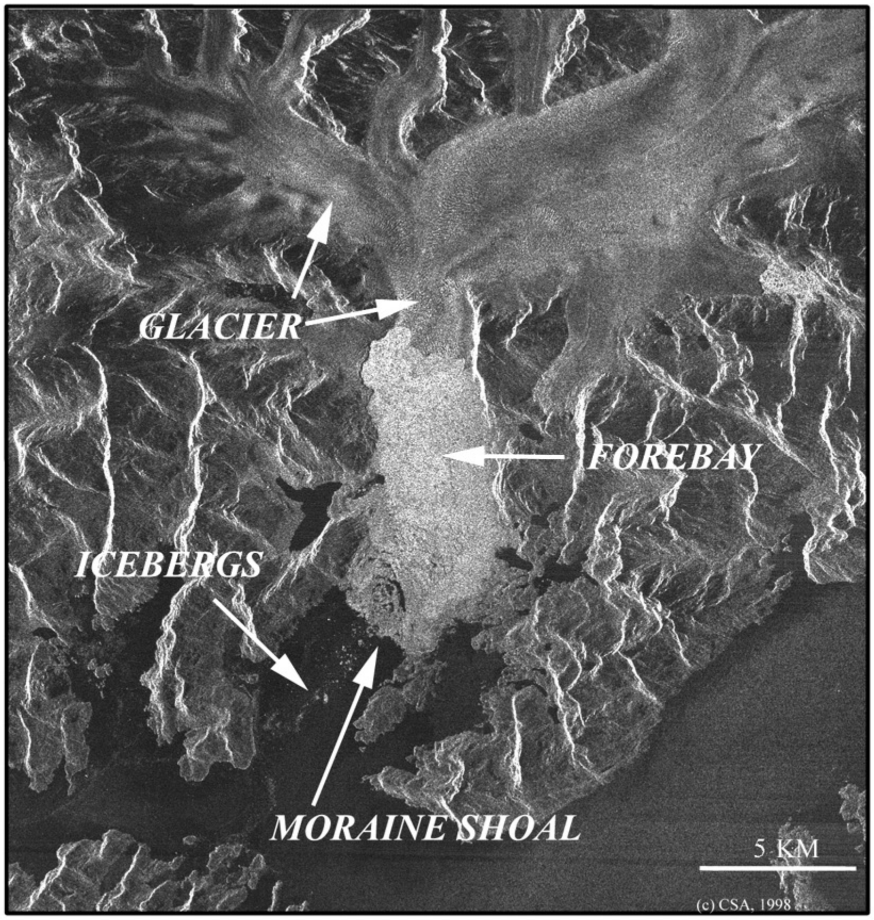


Date: 4/15/99
Time: 17:07:16 GMT
Location:
Bristol Bay
58N, 158W
Mode:
ScanSAR Wide B



Grease ice concentration produces low backscatter signatures in SAR imagery. Grease ice is composed of small millimeter sized crystals that form when seawater begins to freeze. As it accumulates on the sea surface, it may form slick patterns resembling those produced by mineral or biogenic substances.

GLACIERS/ICEBERGS

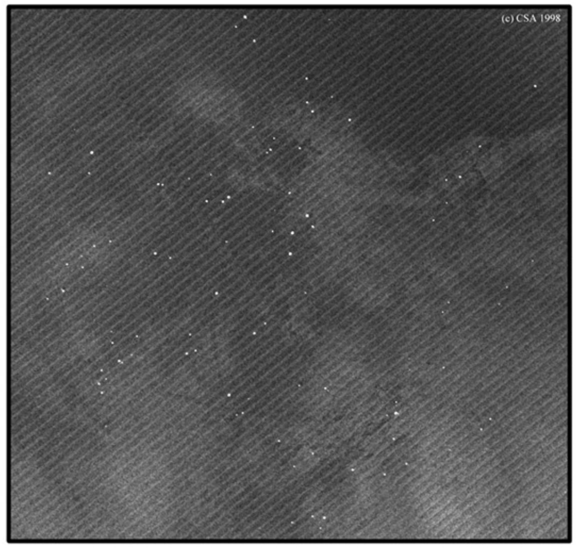


Date: 10/29/98
Time: 3:23:52 GMT
Location:
Prince William Sound
61.1N, 147.1W
Mode: Standard

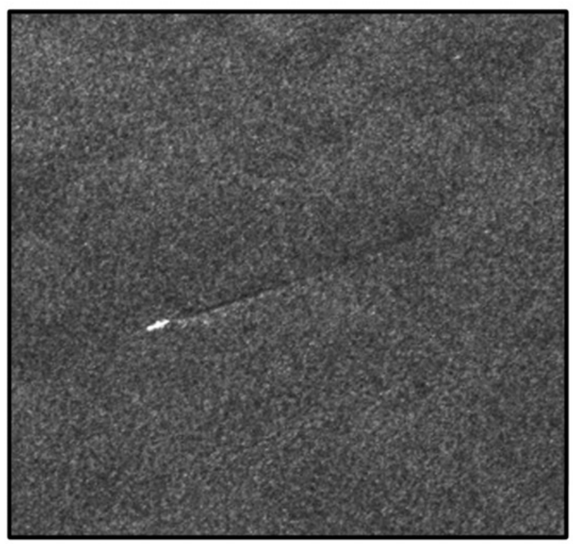
Glaciers and icebergs, like most ice, appear very bright in SAR imagery. Glaciers are often recognizable by long linear features travelling along the glacier's length, and smaller folds along the width. This is an image of the Columbia Glacier in Alaska. Until recently, the glacier ended at a shallow moraine shoal, but now has retreated about 10 km up the fjord. The glacier calves off icebergs that get trapped behind the shoal creating a forebay filled with icebergs and ice. Icebergs that escape can drift into the open ocean and pose a threat to maritime traffic in the region.

SHIPS AND SHIP WAKES

Date: 7/26/98
Time: 18:17:27 GMT
Location:
Bering Sea
61.8N, 179W
Mode:
ScanSAR Wide B

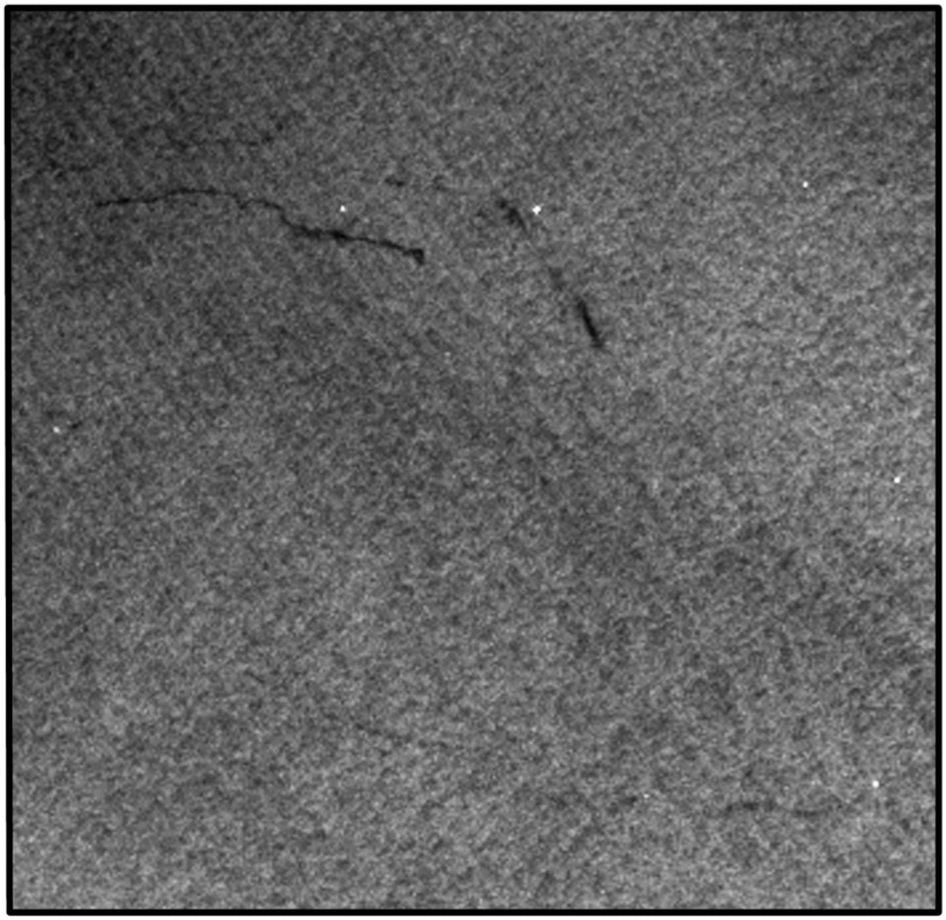


Date: 12/8/97
Time: 16:45:37 GMT
Location:
Gulf of Alaska
59.3N, 152.1W
Mode: Standard



Due to the high reflectivity of ships, SAR can easily detect them as hard targets. Ships appear in SAR imagery as bright dots or spots (Top), sometimes exhibiting wakes (Bottom). High resolution SAR can be used to assess the size and type of vessels observed while ship wakes can provide information on course and speed. A large cluster of the Russian trawl fishing fleet is shown in the image against a relatively low wind speed background. Sea surface background clutter resulting from high winds or small radar incidence angle could make it difficult to detect ships.

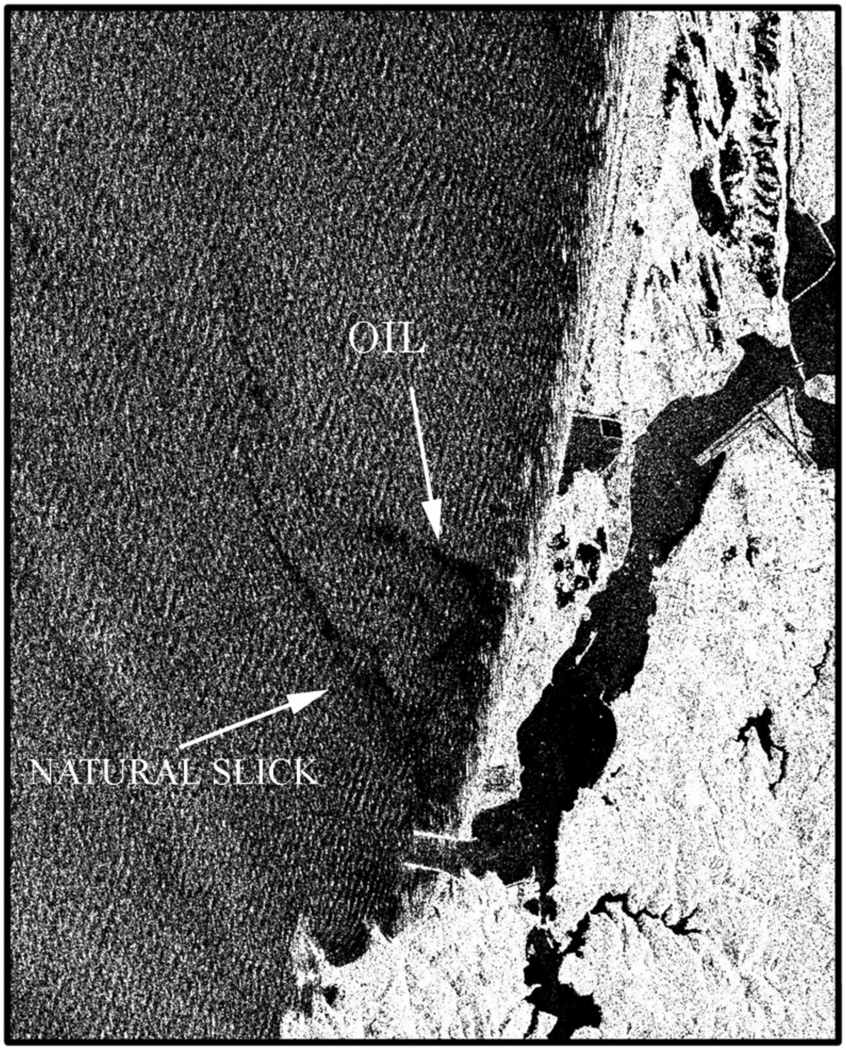
SHIP SLICKS



Date: 11/19/97
Time: 5:38:05 GMT
Location:
Bering Sea
62N, 178W
Mode:
ScanSAR Wide B

Man-made surface slicks can produce similar dark features as natural slicks in SAR imagery. This results from the damping of capillary waves by the slick substances and appears as dark features on SAR imagery. Man-made slicks are commonly the result of accidental spill or intentional dumping of petroleum products as well as the discharge of organic matter resulting from fishing activities. The image shows evidence of discharged fish processing material from trawlers in the Bering Sea.

OIL SPILL

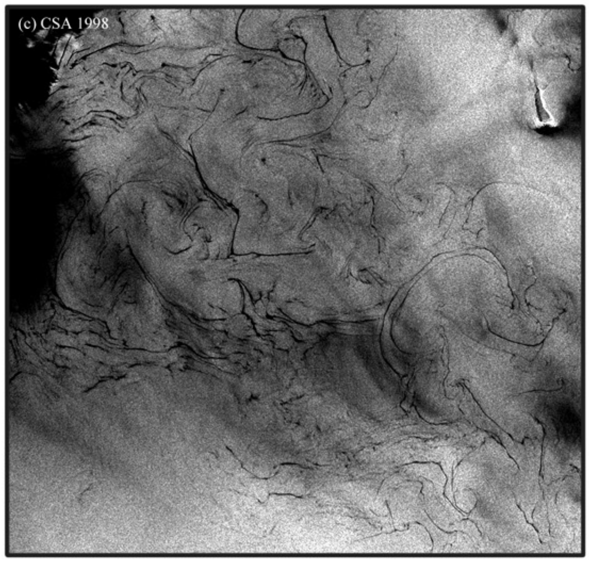


Date: 2/11/99
Time: 14:27:32 GMT
Location:
Coos Bay, OR
43N, 124W
Mode: Wide

Oil can be observed in SAR images when wind speeds exceed 3 meters per second, but are not greater than about 10 meters per second (although some slicks can be visible under higher wind speed conditions when viewing at higher incidence angles). The oil dampens the Bragg waves and thus appears as a darker region in the image. Spills can seldom be unambiguously identified since low wind, upwelling, and natural surfactants can produce similar SAR signatures. The image shows a slick from the New Carissa oil spill in Coos Bay. OR., just north of a natural biogenic slick.

NATURAL SLICKS

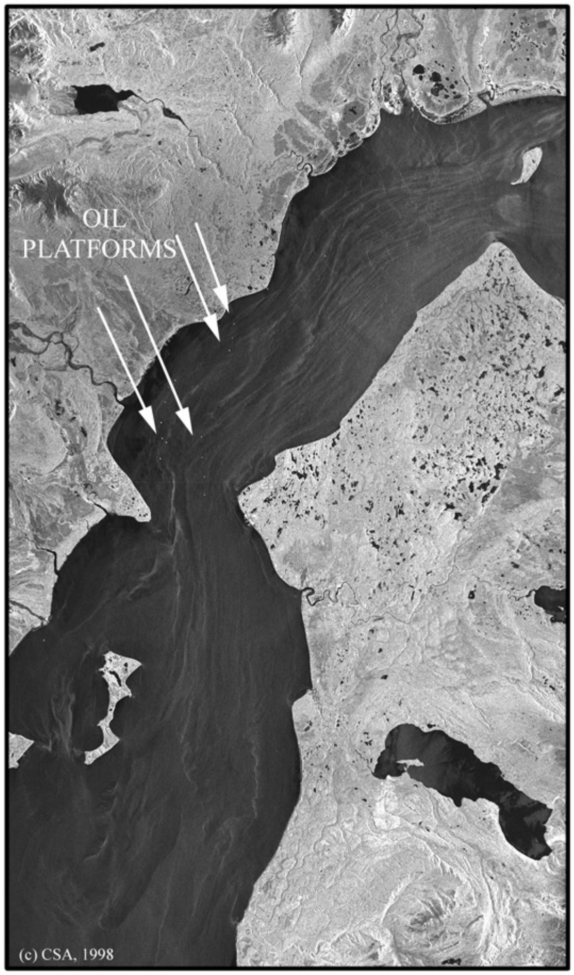
Date: 5/13/98
Time: 17:34:41 GMT
Location:
Bering Sea
64N, 161.5W
Mode: standard



Date: 9/8/98
Time: 3:10:45 GMT
Location:
Gulf of Alaska
58N, 147W
Mode: standard

Natural slicks appear often as dark filamentous features in SAR imagery and can be mineral or biogenic in origin. Natural mineral slicks are commonly observed in areas dominated by ocean-bottom oil seeps such as the Santa Barbara Channel in Southern California or the Gulf of Mexico Green Canyon . Biogenic slicks form because of higher concentrations of organic matter surface-active constituents, of marine or terrigenous origin, at the surface microlayer. Slick dominated areas in SAR imagery have been commonly associated with high biological activity. Natural slicks can provide an indication of the local circulation as shown by the eddy feature on the image.

COOK INLET-STANDARD MODE



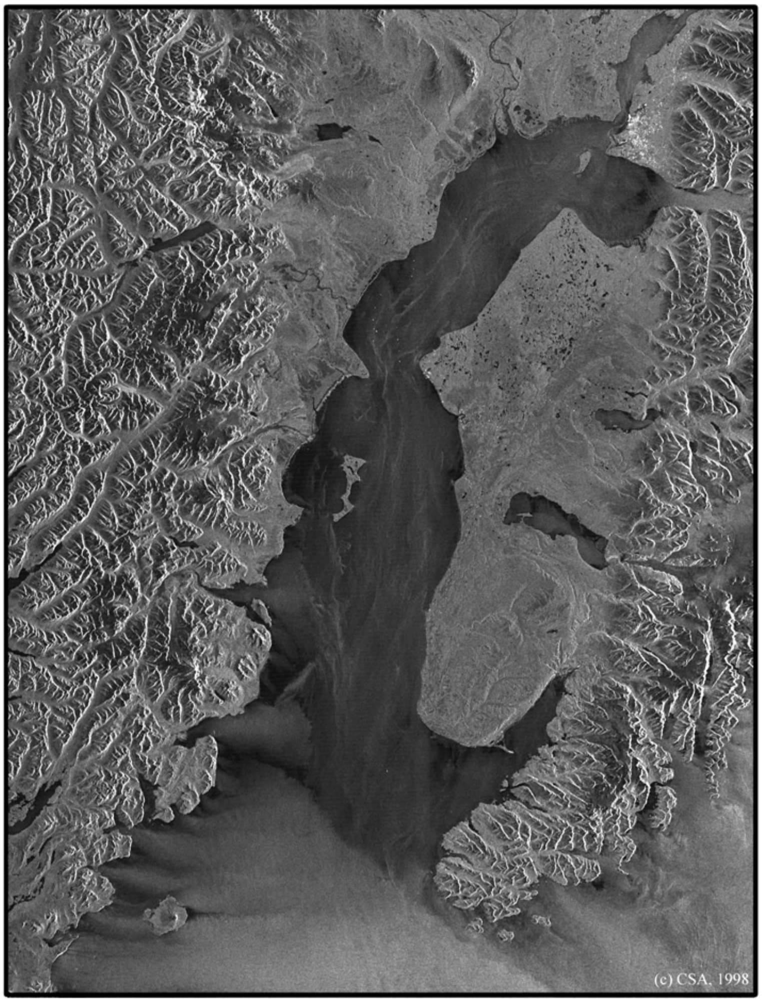
Date: 11/6/98
Time: 16:32:32 GMT
Location:
Cook Inlet
60N, 152W
Mode Standard

Bathymetry is commonly visible in Cook Inlet (see bathymetry) as linear features along the length of the inlet. Also, it is home to multiple oil platforms that appear as small bright spots on the SAR image. Both of these features can be seen in standard mode imagery and ScanSAR Wide B (to less of an extent). In the winter there are flows of ice extending from the north mouth of the inlet near Anchorage.

COOK INLET-STANDARD MODE WITH ICE

Date: 2/13/99
Time: 16:45:44 GMT
Location:
  Cook Inlet
  60N, 152W
Mode: Standard

COOK INLET-SCANSAR WITH NO ICE

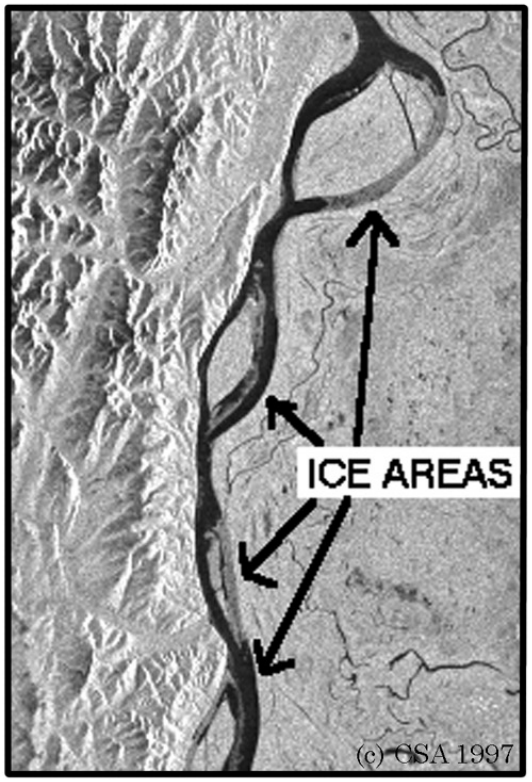


Date: 10/6/98
Time: 16:37:10 GMT
Location:
Cook Inlet
60N, 152W
Mode:
ScanSAR Wide B

COOK INLET-SCANSAR WITH ICE

Date: 3/4/99
Time: 3:48:30 GMT
Location:
Cook Inlet
60N, 132W
Mode:
ScanSAR Wide B

RIVER ICE



Date: 5/12/97
Time: 17:08 GMT
Location:
Yukon River
Mode: Standard

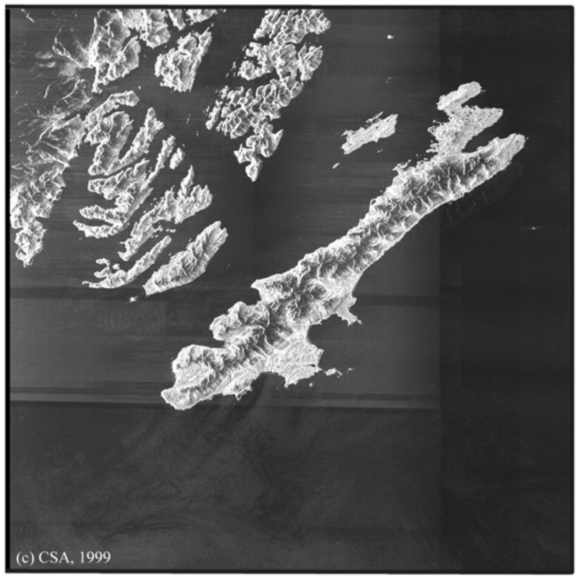
High resolution SAR imagery is useful for monitoring river ice conditions, spring ice breakup, ice runs, and flooding due to ice jams. In this image of the Yukon River, the main channel appears to be open with some running ice. Ice in the upper slough may be intact or may be jammed chunk ice.

VOLCANO

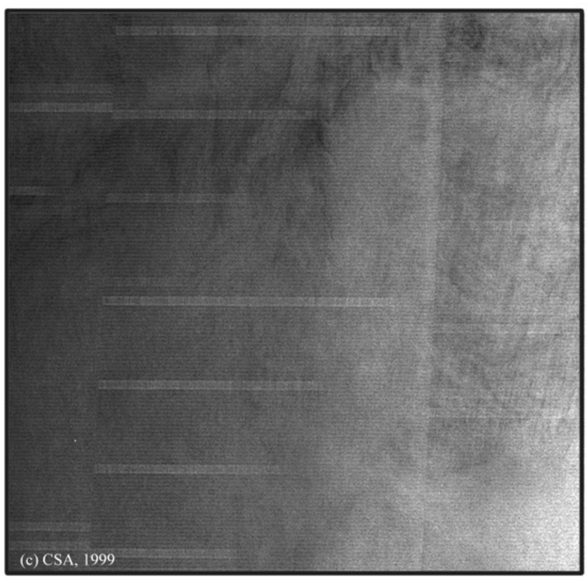
Date: 4/13/99
Time: 4:21:03 GMT
Location:
Shishaldin Volcano
56N, 156W
Mode:
Standard

DATA QUALITY PROBLEMS

Date: 6/12/99
Time: 3:31:56 GMT
Location:
Prince William Sound
60N, 147W
Mode: Standard



Date: 6/13/99
Time: 18:27:33 GMT
Location:
Bering Sea
55N, 180
Mode:
ScanSAR Wide B



DATA QUALITY PROBLEMS

Date: 6/13/99
Time: 4:44:06 GMT
Location:
St. Lawrence Is
63.5N, 171W
Mode:
ScanSAR Wide B

Date: 6/16/99
Time: 16:59:02 GMT
Location:
Alaska Penninsula
63.5N, 171W
Mode:
ScanSAR Wide B